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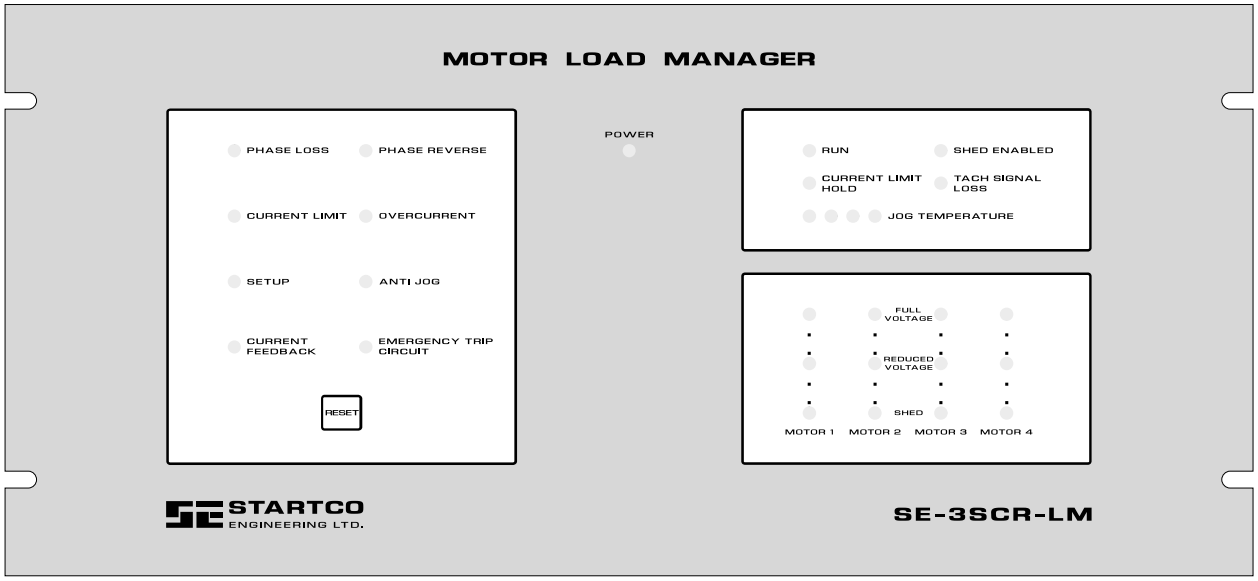
SE-3SCR-LM MANUAL

MOTOR LOAD MANAGER

OCTOBER 24, 2006

REVISION 3



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DISCLAIMER

1. GENERAL

Each Startco solid-state starter uses one Load Manager to control the power applied to three-phase, squirrel-cage induction motors in one-, two-, three-, or four-motor configurations. The SE-3SCR-LM Motor Load Manager control module replaces the SE-2SCR-LC, SE-2SCR, and SE-1SCR control modules. The Load Manager is standard in new equipment and it can be retrofitted to existing Startco starters to provide the following additional features:

- On-board, active and passive digital-tachometer inputs.
- Adjustable current-limit-hold trip time.
- Isolated run-signal and remote-reset inputs.
- Run, trip, and full-conduction relay outputs.
- On-board, emergency-trip circuit with an output contact for shunt or undervoltage breaker control.
- Individual control of each motor for smooth shed and share transitions.
- Choice of current-shed or forced-shed operation.
- Reduced-voltage-run adjustment for each motor in a multiple-motor drive to allow load sharing.

A silicon-controlled rectifier (SCR) is an electrically operated switch that can be gated into conduction by applying a trigger pulse to its gate terminal. Once an SCR is gated on, it will remain on until current drops below a low value called the holding current. In ac applications, this happens each cycle on the negative zero crossing; consequently, SCR's can be used to control ac voltage by triggering the SCR's into conduction once each cycle. The portion of the cycle in which current flows is called the conduction angle. In Startco Solid-State Starters, conduction-angle signals from the Load Manager initiate SCR trigger pulses generated by firing circuits in the power modules.

A Startco power module has an SCR and a diode in a parallel, back-to-back configuration. Three power modules are used to control the voltage applied to a three-phase motor. The Load Manager uses either current or tachometer feedback to adjust SCR conduction angles during a start to bring a load smoothly up to speed. A reduced-voltage indicator flashes whenever a conduction angle is changing. Once full speed has been achieved and full voltage is indicated, the SCR's are gated full-on so that currents are the same as they would be if the power modules were replaced by contacts.

2. CURRENT-FEEDBACK OPERATION

Load Manager adjustments are functionally grouped as shown in Fig. 1.

For current-feedback starts, the top switch in the TACHOMETER FEEDBACK START group must be in the NO position. When this switch is in the NO position, all other controls in the TACHOMETER FEEDBACK START group are disabled.

2.1 MINIMUM ACCELERATION TIME

The MINIMUM ACCELERATION TIME control is a 16-position selector switch that sets the time for motor voltage to increase from initial voltage to full voltage without a current-limit hold. Each clockwise step above 3 seconds increases the minimum time to reach full voltage by 1.5 seconds. The REDUCED VOLTAGE indicator flash rate is proportional to the rate at which motor voltage is changing.

2.2 CURRENT-LIMIT-HOLD LEVEL

The CURRENT LIMIT HOLD LEVEL control is a 16-position selector switch that sets the current limit during a current-feedback start. The selection range is 200% to 500% of motor full-load current (FLA). Each clockwise step increases the current-limit-hold level by 20% FLA. During a current-feedback start, voltage will increase at a rate set by the MINIMUM ACCELERATION TIME control; however, if the load is sufficient to cause any motor current to reach the current-limit-hold level, the CURRENT LIMIT HOLD indicator will come on, the REDUCED VOLTAGE indicators will stop flashing, and the conduction angle will not advance until all motor currents fall below the current-limit-hold level. As the load accelerates, current decreases and voltage will continue to increase until full conduction is reached.

2.3 CURRENT-LIMIT-HOLD TRIP TIME

The CURRENT LIMIT HOLD TRIP TIME control is a 16-position selector switch that sets the cumulative trip time for current-limit hold. The selection range is 2 seconds to 32 seconds in 2-second increments. When configured for DOUBLE TRIP TIME in the CONFIGURATION group, the selection range is 4 seconds to 64 seconds in 4-second increments. In most applications, the CURRENT LIMIT HOLD indicator should come on momentarily during a heavily loaded start. If unnecessary current-limit trips occur, increase MINIMUM ACCELERATION TIME, increase CURRENT LIMIT HOLD LEVEL, or increase CURRENT LIMIT HOLD TRIP TIME.

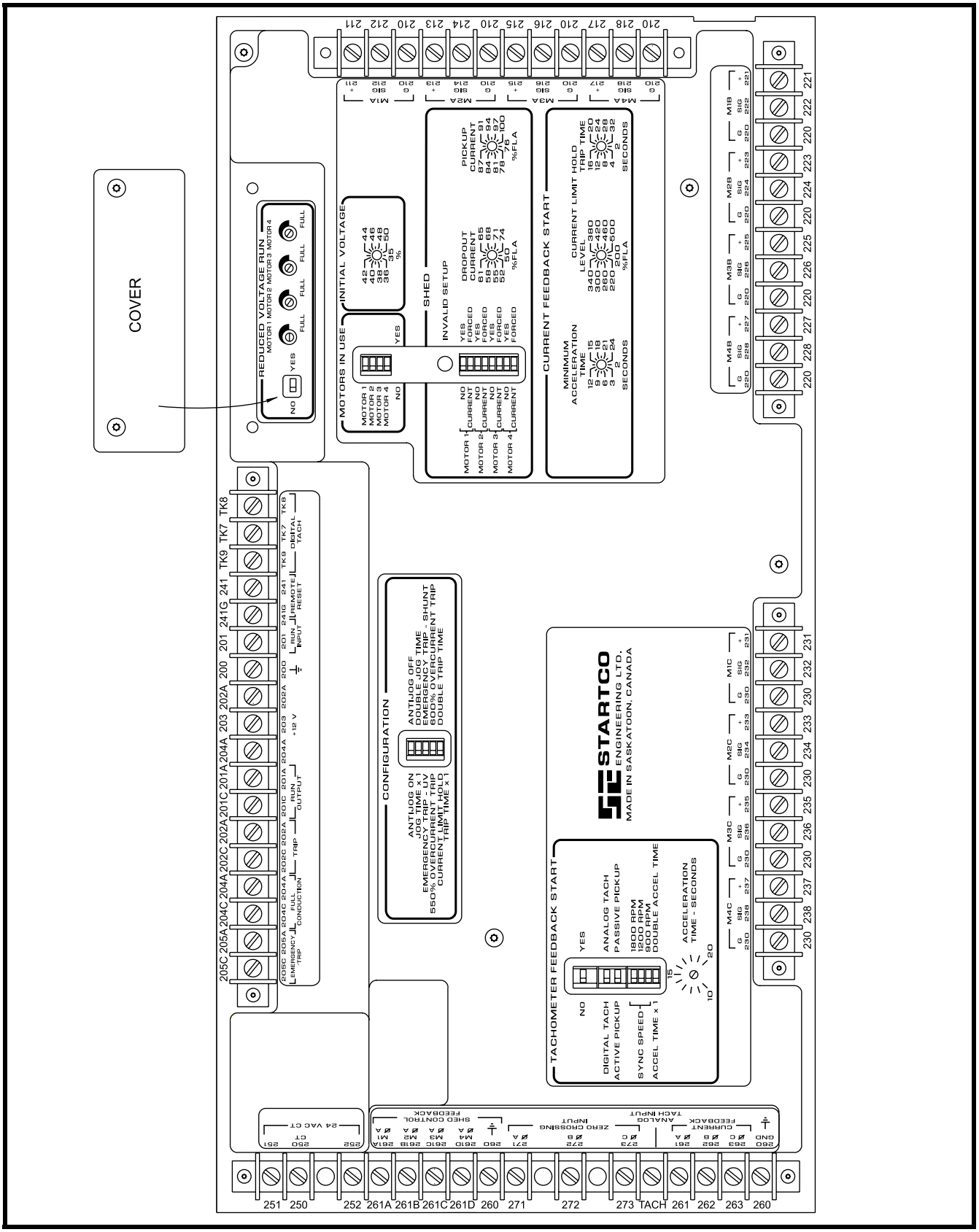


FIGURE 1. SE-3SCR-LM Rear View.

2.4 INITIAL VOLTAGE

The INITIAL VOLTAGE control is a 16-position selector switch that sets the voltage applied to the motors at the beginning of the start. The selection range is 35% to 50% of full voltage in 1% increments. A setting of 38% to 42% will be sufficient for most applications. The INITIAL VOLTAGE control should be set so that torque is applied smoothly and shaft rotation begins without delay. If the initial-voltage setting is too high, the Load Manager will trip on overcurrent at the beginning of the start.

3. TACHOMETER-FEEDBACK OPERATION

Load Manager adjustments are functionally grouped as shown in Fig. 1.

For tachometer-feedback starts, the top switch in the TACHOMETER FEEDBACK START group must be in the YES position. When this switch is in the YES position, all controls in the TACHOMETER FEEDBACK START group are enabled, and all controls in the CURRENT FEEDBACK START group must be set to their maximum settings.

The tachometer-feedback circuit accepts an analog tachometer, an active digital tachometer, or a passive digital tachometer. Separate inputs are provided for analog and digital tachometers. The SE-3SCR-LM must be configured for the type of tachometer used. See Section 6.4. Set one of the SYNC SPEED switches to program the tachometer circuit for 900, 1200, or 1800 rpm.

In tachometer-feedback start, motor voltage is adjusted automatically to cause the motors to accelerate at a constant rate. The TACHOMETER FEEDBACK START ACCELERATION TIME potentiometer adjusts acceleration time from 10 seconds to 20 seconds. When DOUBLE ACCEL TIME is selected, acceleration time is doubled. REDUCED VOLTAGE indicators flash slowly while the tachometer-feedback circuit has control of motor voltage. When 97% of synchronous speed is reached, motor voltage is increased to full voltage in 1.5 seconds.

In tachometer-feedback start, the function of the INITIAL VOLTAGE selector is changed—it limits maximum motor voltage during starting. If the INITIAL VOLTAGE selector is set too high, an OVERCURRENT trip can occur during a heavily loaded start. For most applications, an initial-voltage setting of 44% will be adequate; however, the setting should be increased if load acceleration droops during a start. If the INITIAL VOLTAGE selector is set correctly, motors will be permitted to draw up to 450% full-load current during a heavily loaded start.

4. TRIP INDICATIONS

All Load Manager trips are annunciated by the front-panel indicators shown in Fig. 2. Trips remain latched until the trip condition is removed and RESET is pressed or the supply voltage is cycled.

4.1 PHASE LOSS

A phase-loss trip will occur if any of the zero-crossing signals are not detected, or if the zero-crossing signals are not displaced 120° with respect to each other.

4.2 PHASE REVERSE

A phase-reverse trip will occur if all zero-crossing signals are detected and their phase sequence is not A-B-C.

4.3 CURRENT LIMIT

A current-limit trip will occur if motor current exceeds the current-limit-hold level for the current-limit-hold trip time.

4.4 OVERCURRENT

An overcurrent trip will occur if current to any motor exceeds the overcurrent-trip level. The overcurrent-trip level can be selected at 550% or 600% FLA by a switch in the CONFIGURATION group.

4.5 SETUP

A setup trip will occur if the SHED switches and REDUCED VOLTAGE RUN potentiometer settings do not allow at least one of the motors in use to run at full voltage. A valid setup requires at least one of the motors in use to have its SHED switch set to NO and its REDUCED VOLTAGE RUN potentiometer set to FULL. To assist in setup, the rear-panel INVALID SETUP indicator mimics the front-panel SETUP trip indicator.

4.6 ANTI JOG

An anti-jog trip will occur if JOG TEMPERATURE reaches a count of 14. An anti-jog trip will remain latched until JOG TEMPERATURE counts down to 4. The top two switches in the CONFIGURATION group can be used to enable or disable anti-jog trips and to double the time to trip. See Section 5.5.

4.7 CURRENT FEEDBACK

A current-feedback trip will occur during starting or running if less than 12% FLA is detected for any motor in use.

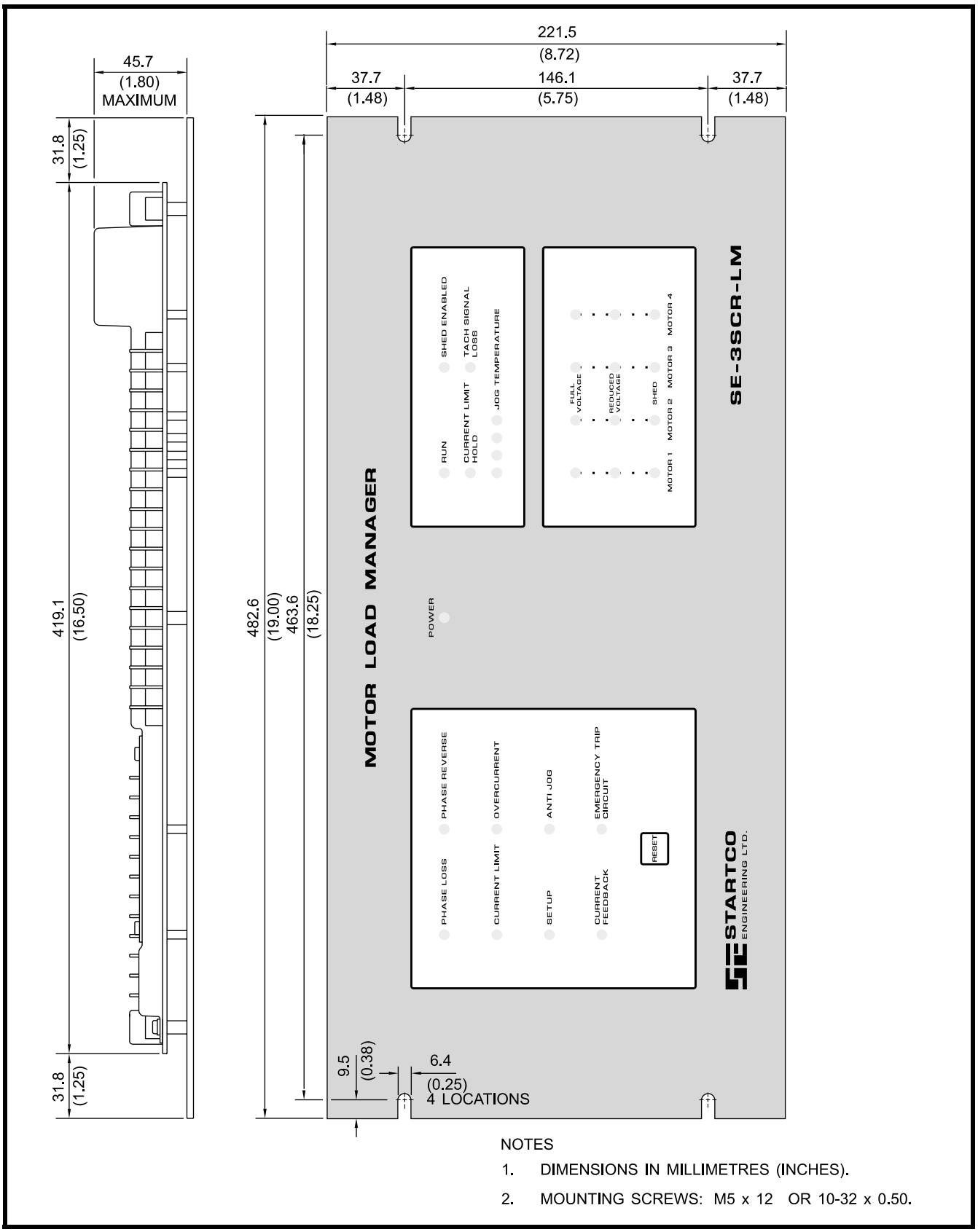


FIGURE 2. SE-3SCR-LM Outline and Mounting Detail.

4.8 EMERGENCY-TRIP CIRCUIT

An emergency-trip-circuit trip will occur if motor current (above 12% FLA) continues for more than 3.5 seconds after the run signal is removed. Emergency-trip-circuit protection is similar to "welded-contact" protection. Circuit operation is SHUNT or UV selectable with a switch located in the CONFIGURATION group. Output contacts can be used in a breaker or interposed contactor control circuit.

5. OTHER INDICATION

5.1 RUN

The green LED labelled RUN indicates a 12- to 24-Vdc run signal on terminal 201 when the Load Manager is not tripped.

5.2 SHED ENABLED

The yellow LED labelled SHED ENABLED indicates that at least one of the motors in use has its SHED switch set to YES.

5.3 CURRENT-LIMIT HOLD

The red LED labelled CURRENT LIMIT HOLD indicates that motor current has reached the current-limit-hold level.

5.4 TACH SIGNAL LOSS

The yellow LED labelled TACH SIGNAL LOSS indicates that the tachometer-feedback signal lags the reference speed signal by more than 6% of synchronous speed. Tach-signal loss does not cause a trip.

5.5 JOG TEMPERATURE

An MPU Motor Protection Unit or an MPS Motor Protection System is recommended for each motor; however, the jog-temperature circuit can provide protection in the event of repeated starts. Four yellow LED's labelled JOG TEMPERATURE indicate the recent starting history of the starter. The LED's have a binary weighting of 8, 4, 2, and 1 from left to right and the number in the jog temperature display is obtained by adding the binary value of the LED's that are on. Values assigned to this display are: 0 is cold, 4 is normal run, and 14 is trip. Two, successive, maximum-acceleration-time starts are allowed if the motors are stopped on normal run; however, if a third start is attempted, the anti-jog circuit will trip at 14 and not allow a reset until the display decrements to 4. This will take approximately 11 minutes.

Time to trip can be doubled with a switch in the CONFIGURATION group. The top switch in the CONFIGURATION group can be used to disable anti-jog trips.

5.6 MOTOR VOLTAGE

The status of the voltage applied to each motor in use is indicated by three LED's. The bottom LED indicates if the motor is SHED, the middle LED indicates if the motor is operating at REDUCED VOLTAGE and it flashes when motor voltage is changing, and the top LED indicates FULL VOLTAGE.

6. INITIAL SETUP AND COMMISSIONING

6.1 MOTORS IN USE

Set the MOTORS IN USE switches to the YES position for each motor used. If a motor is selected but not used, feedback current will not be detected and a current-feedback trip will occur within 3 seconds. If a motor is connected but not selected, it will not receive power. All unused feedback inputs (261, 262, 263, 261A, 261B, 261C, and 261D) should be connected to terminal 260.

> **NOTE:** To prevent a feedback trip during troubleshooting when no motor is connected, set the MINIMUM ACCELERATION to 2 seconds.

6.2 INITIAL VOLTAGE

Set the INITIAL VOLTAGE selector to 40% for current-feedback starts or 44% for tachometer-feedback starts. See Sections 2.4 and 3.

6.3 CURRENT-FEEDBACK START

If current feedback is used, set the top switch in the TACHOMETER FEEDBACK START group to NO, set the MINIMUM ACCELERATION TIME selector to 15 seconds, set the CURRENT LIMIT HOLD LEVEL selector to 460% FLA, and set the CURRENT LIMIT HOLD TRIP TIME to 6 seconds.

6.4 TACHOMETER-FEEDBACK START

If tachometer feedback is used, set the top switch in the TACHOMETER FEEDBACK START group to YES and set all controls in the CURRENT FEEDBACK START group to their maximum settings.

6.4.1 ANALOG TACHOMETER

1. Set switch to ANALOG TACH.
2. Connect the positive output of a 100-Vdc/1000-rpm tachometer to the terminal labelled ANALOG TACH INPUT and connect the negative output to terminal 260.
3. Set one SYNC SPEED switch for 900, 1200, or 1800 rpm.
4. Set the acceleration-time switch to ACCEL TIME x1.
5. Set the ACCELERATION TIME potentiometer to 15 seconds.

6.4.2 DIGITAL TACHOMETER

The Load Manager accepts speed signals from a passive digital tachometer or a 12-Volt active digital tachometer.

1. Set switch to DIGITAL TACH.
2. Set switch to ACTIVE PICKUP or PASSIVE PICKUP to correspond with the pickup used.
3. Connect the pickup signal lead to terminal TK7 and the ground lead to terminal TK8. Ground the shield only at terminal TK8. If a passive pickup is used, leave terminal TK9 unconnected. If an active pickup is used, connect the 12-Vdc lead to TK9.
4. Set one SYNC SPEED switch for 900, 1200, or 1800 rpm.
5. Set the acceleration-time switch to ACCEL TIME x1.
6. Set the ACCELERATION TIME potentiometer to 15 seconds.

6.5 CONFIGURATION

Commission the system with the CONFIGURATION group set as follows:

- ANTI JOG ON.
- JOG TIME x1.
- EMERGENCY TRIP to match breaker operating mode.
- 550% OVERCURRENT TRIP.
- CURRENT LIMIT HOLD TRIP TIME x1.

6.6 SHED

Commission the system with the SHED switches set to the NO and CURRENT positions. After the system is operational, the benefits of motor shedding for the application can be determined as outlined in Section 7.

6.7 REDUCED-VOLTAGE RUN

Commission the system with the REDUCED VOLTAGE RUN potentiometers fully clockwise and the REDUCED VOLTAGE RUN switch to NO. After the system is operational, the benefits of motor sharing for the application can be determined as outlined in Section 8.

7. MOTOR-SHED CONTROL

Two shed-control switches are used for each motor. If the upper switch is in the NO position, shed control is disabled for that motor. If the upper switch is in the YES position, the lower switch is active and its position determines if the motor will be forced off 15 seconds after full conduction or if the motor will drop-out and pick-up as the load changes. The DROPOUT CURRENT and PICKUP CURRENT selector switches apply only to motors with their shed switches in the YES and CURRENT positions.

The current-shed circuit monitors motor currents from the phase-A feedback CT's of each motor. DROPOUT CURRENT and PICKUP CURRENT selectors adjust the thresholds at which motors drop-out and pick-up. The drop-out current range is 50 to 74% of motor FLA and the pick-up current range is 76 to 100% of motor FLA. If all phase-A currents remain below the drop-out current, the current-shed-enabled motors will be sequentially turned off starting with motor 4. The drop-out rate is one motor per 3 minutes. If any phase-A current is more than the pick-up current, motors will be sequentially turned on starting with Motor 1. The pick-up rate is one motor per 10 seconds.

At least one MOTOR IN USE must have its SHED switch in the NO position and its REDUCED VOLTAGE RUN potentiometer set to FULL. Setting the REDUCED VOLTAGE RUN switch to NO is equivalent to setting all REDUCED VOLTAGE RUN potentiometers to FULL.

8. REDUCED-VOLTAGE RUN

The Load Manager can reduce the steady-state voltage for all motors except one in a multiple-motor drive. A REDUCED VOLTAGE RUN potentiometer for each motor can reduce applied voltage to 45%. The purpose of voltage reduction is to balance motor currents in a multiple-motor drive; however, if motors are lightly loaded, power factor will be low and load sharing will not be effective. If all motors in a multiple-motor drive run below 80% FLA at 100% voltage, there is little benefit in using the REDUCED VOLTAGE RUN controls.

For effective load-share operation, the motor chosen to remain at full voltage should be the motor with the lowest running current. Load will shift to this motor as other motors in the drive have their voltages reduced.

After a successful start, full voltage will be applied to all selected motors. After 5 seconds, motor voltages will ramp down (at the MINIMUM ACCELERATION TIME rate) to the voltages set by their respective REDUCED VOLTAGE RUN potentiometers.

9. TROUBLESHOOTING

Reference: Fig. 3a, Fig. 3b.

CAUTION: Power modules, heat sinks, and motor cables can be energized even if a motor is not running. If a motor is stopped, diodes in the power modules provide half-wave rectification with respect to ground. If a motor is disconnected, current through snubber networks in the power modules is sufficient to be lethal. Use the same precautions and safety procedures for both line-side and load-side measurements and service.

The following troubleshooting procedure requires a dc voltmeter. All voltage measurements on the SE-3SCR-LM are with respect to terminal 260.

1. Turn all motor circuit breakers off.
2. To prevent a CURRENT FEEDBACK and EMERGENCY TRIP CIRCUIT TRIP during testing, set the MINIMUM ACCELERATION to 2 seconds. It is recommended to disconnect the motor and to use a 3-wire light bulb load for these tests. However when motors are connected, the gate leads at terminals **G** and **C** on the firing card should be removed to prevent SCR gate triggering during the test.
3. Set the top switch in the TACHOMETER FEEDBACK START group to NO, the REDUCED VOLTAGE RUN switch to NO, all MOTORS IN USE switches to YES, all SHED switches to NO, and the MINIMUM ACCELERATION TIME switch to 2 seconds.
4. Turn on circuit breaker to motor 1 to restore zero-crossing signals to the Load Manager. If the light bulb load lights are ON or if motor current is detected go to step 6. Press RESET on the Load Manager. Apply a run signal to terminal 201. The reduced-voltage indication should flash until full voltage is reached. Measure the voltages on terminals 210 to 236. Starting at terminal 211 and working clockwise toward terminal 230, the voltage pattern 12, 2, 0 Vdc should be measured. The voltage at odd-numbered terminals is 12 Vdc, and the voltage at even-numbered terminals is 2 Vdc except for terminals ending with a 0. The voltage at terminals ending with a 0 is 0 Vdc. If this voltage pattern is not observed, remove the output connections and repeat the measurements. If the voltage pattern is correct with outputs disconnected, the Load Manager is not defective and there is a problem with the firing boards or the interconnecting cables. The voltages on even-numbered terminals should be 0 Vdc when the run signal is removed.
5. With the Load Manager in full conduction, input signals to the firing boards should also be 12, 2, and 0 Vdc. When using a light bulb load, intensity should be balanced. If intensity is unbalanced, test or replace the three firing boards. To check a firing board, connect a 1-kΩ resistor between terminals **G** and **C** and measure the voltage across the resistor. The voltage should be 6 Vdc when the Load Manager indicates full voltage and 0 Vdc when the Load Manager is off.
6. To check the SCR and the diode, remove the connecting bar on the split heat sink. The diode can be checked by an ohmmeter with a diode-test function and the SCR can be checked with the test circuit shown in Fig. 3.

10. TECHNICAL SPECIFICATIONS

Supply:
24 Vac (±30%), centre-tapped, 60 Hz, 10 VA

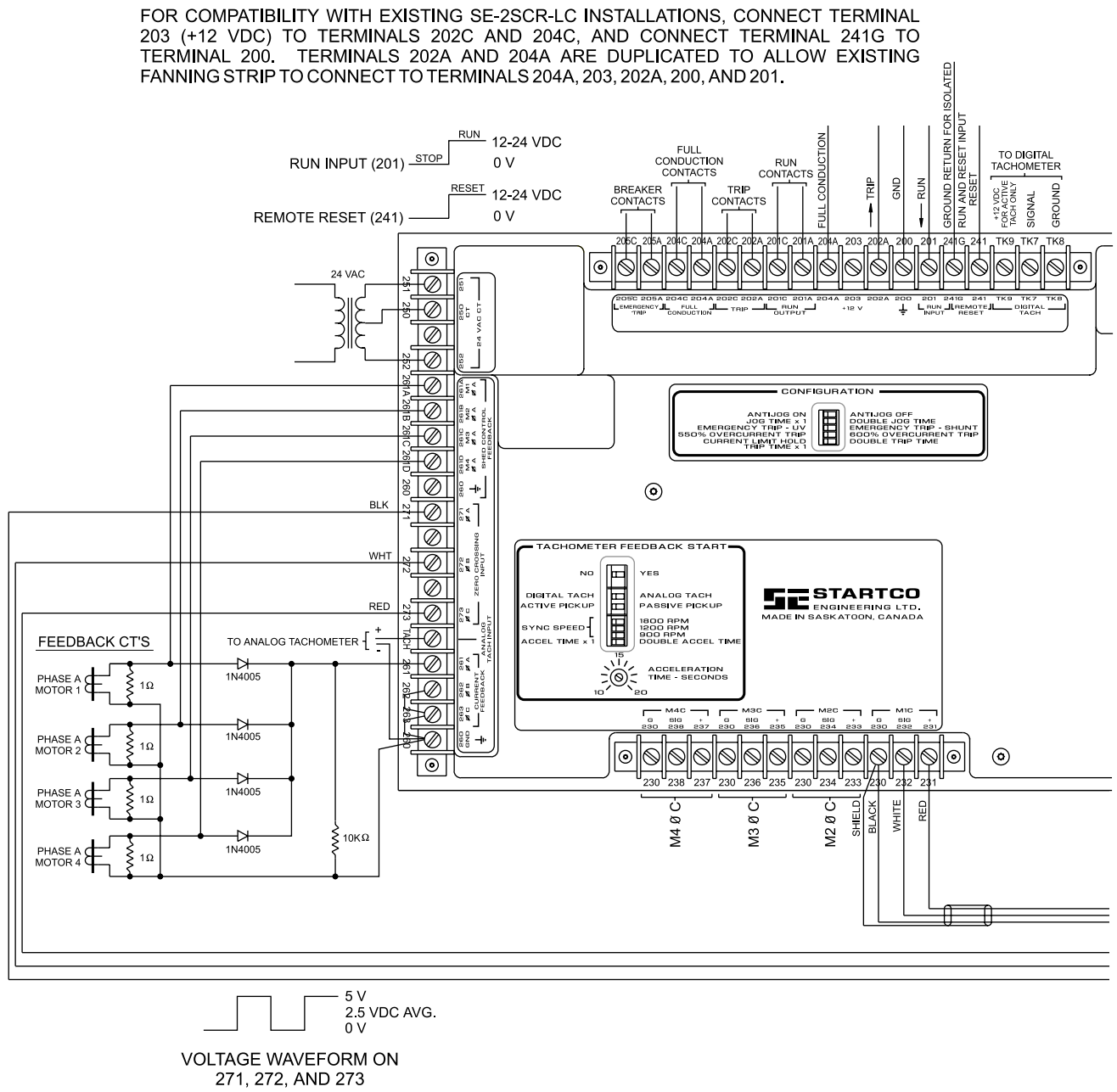
Environment:
Operating Temperature ..... -40°C to 60°C
Storage Temperature ..... -55°C to 80°C

Output Relays:
Trip, Run:
Contact Rating ..... 600 mA Resistive, 120 Vac or 120 Vdc. 2 A Resistive @ 30 Vdc.
Contact Configuration ..... Form A
Operating Mode ..... Fail-Safe
Emergency Trip Circuit:
Contact Rating ..... 8 A Resistive, 250 Vac or 30 Vdc
Contact Configuration ..... Form A
Operating Mode ..... Fail-Safe or Non-Fail-Safe
Full Conduction:
Contact Rating ..... 8 A Resistive, 250 Vac or 30 Vdc
Contact Configuration ..... Form A

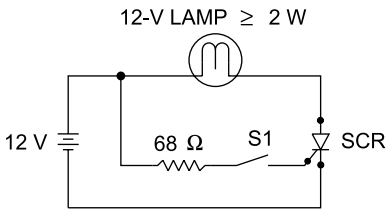
Reset Input Voltage (241) ..... 12 to 24 Vdc with Respect to 241G
Run Input Voltage (201) ..... 12 to 24 Vdc with Respect to 241G

Circuit Accuracies:
Shed Inputs (261A-261D) ..... ±4% FLA
Current-Feedback Inputs (261-263) ..... ±4% of Full Scale

Tachometer Requirements:
Digital:
Pulses Per Revolution 60
Active Pickup Supply Voltage ..... 12 Vdc
Active Input Threshold ..... 2.5 Vdc
Passive Input Threshold ... 50 mV
Analog:
Volts Per 1000 rpm ..... 100 Vdc



VOLTAGE WAVEFORM ON
271, 272, AND 273

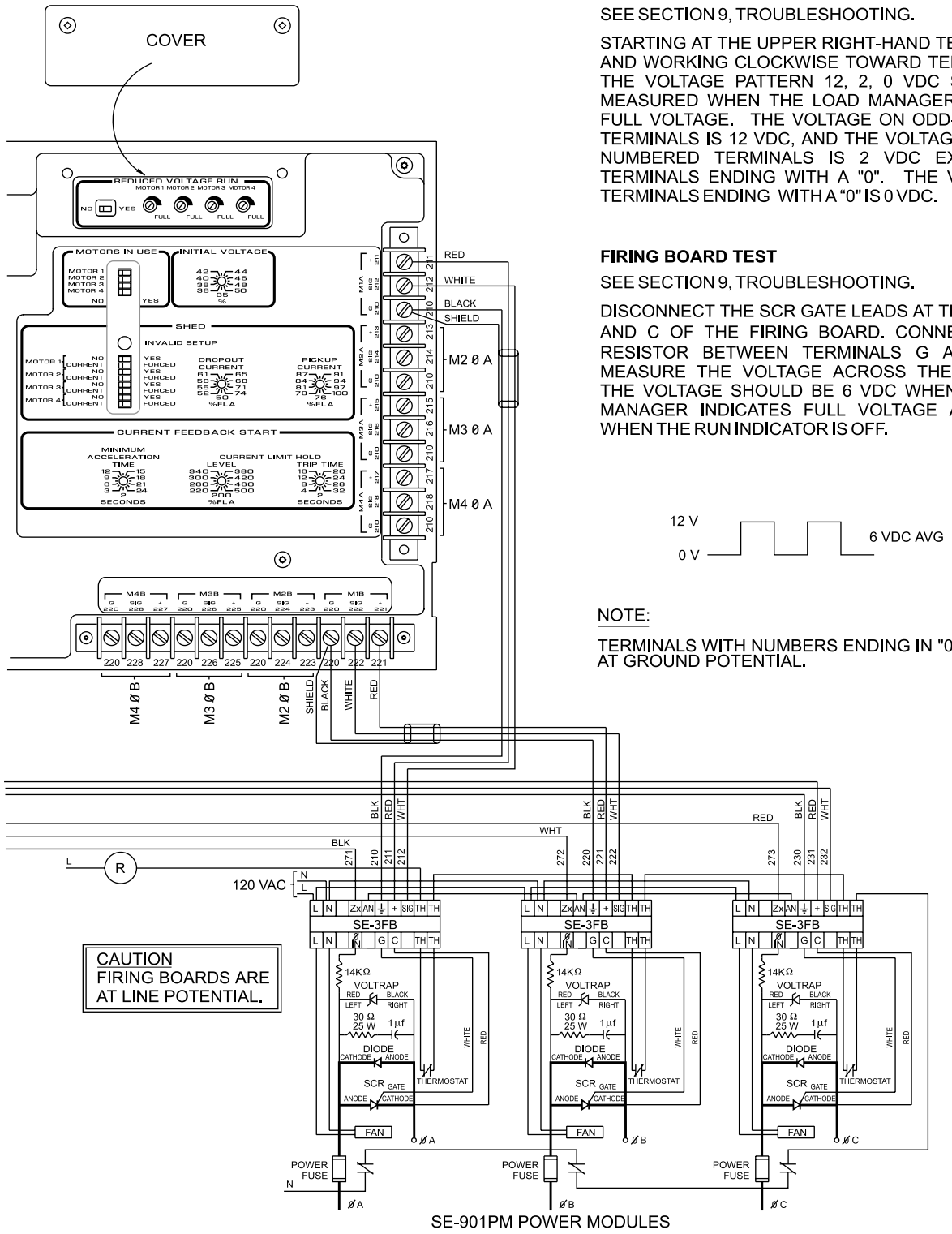


POWER DEVICE TESTS

THIS CIRCUIT CAN BE USED TO CHECK AN SCR. MOMENTARILY CLOSE SWITCH S1. THE LAMP SHOULD COME ON AND REMAIN ON UNTIL THE 12-V SUPPLY IS DISCONNECTED. THIS IS AN OPERATIONAL TEST ONLY AND DOES NOT CHECK THE SCR'S FORWARD OR REVERSE BLOCKING CAPABILITY.

MEASURED WITH AN OHMMETER, THE SCR SHOULD HAVE HIGH IMPEDANCE IN BOTH DIRECTIONS. THE PARALLEL DIODE SHOULD HAVE A LOW IMPEDANCE IN ONE DIRECTION AND HIGH IMPEDANCE IN THE OPPOSITE DIRECTION.

FIGURE 3a. Troubleshooting Guide.



CONTROL OUTPUTS TEST

SEE SECTION 9, TROUBLESHOOTING.

STARTING AT THE UPPER RIGHT-HAND TERMINAL 211 AND WORKING CLOCKWISE TOWARD TERMINAL 230, THE VOLTAGE PATTERN 12, 2, 0 VDC SHOULD BE MEASURED WHEN THE LOAD MANAGER INDICATES FULL VOLTAGE. THE VOLTAGE ON ODD-NUMBERED TERMINALS IS 12 VDC, AND THE VOLTAGE ON EVEN-NUMBERED TERMINALS IS 2 VDC EXCEPT FOR TERMINALS ENDING WITH A "0". THE VOLTAGE AT TERMINALS ENDING WITH A "0" IS 0 VDC.

FIRING BOARD TEST

SEE SECTION 9, TROUBLESHOOTING.

DISCONNECT THE SCR GATE LEADS AT TERMINALS G AND C OF THE FIRING BOARD. CONNECT A 1-KΩ RESISTOR BETWEEN TERMINALS G AND C AND MEASURE THE VOLTAGE ACROSS THE RESISTOR. THE VOLTAGE SHOULD BE 6 VDC WHEN THE LOAD MANAGER INDICATES FULL VOLTAGE AND 0 VDC WHEN THE RUN INDICATOR IS OFF.

NOTE:

TERMINALS WITH NUMBERS ENDING IN "0" ARE AT GROUND POTENTIAL.

FIGURE 3b. Troubleshooting Guide.